

CLAIMS

We claim:

- 1 1. A method for treating a metal-containing liquid, wherein the metal-containing liquid
2 also comprises reducing agents, the method comprising:
3 providing a reaction vessel containing an anode, a cathode, and a hydrogen
4 ion-permeable membrane separating the anode and the cathode;
5 disposing the metal-containing liquid to be treated in the reaction vessel in
6 contact with the anode;
7 disposing a catholyte solution in contact with the cathode;
8 a first placing of the anode and cathode in electrical communication with a
9 power source and driving an electrical current through the anode and the cathode until
10 at least a majority of the reducing agents in the metal-containing liquid are oxidized to
11 create an intermediate liquid and a used catholyte solution;
12 removing the used catholyte solution from contact with the cathode and the
13 intermediate liquid from contact with the anode, optionally from the reaction vessel
14 separately to a first and a second reservoir respectively;
15 disposing the intermediate liquid in contact with the cathode;
16 disposing an anolyte solution in contact with the anode; and
17 a second placing of the anode and cathode in electrical communication with a
18 power source and driving an electrical current through the anode and the cathode until
19 a majority of the metal ions in the intermediate liquid are plated onto the cathode to
20 provide a treated solution.
- 1 2. The method of claim 1, wherein the catholyte solution is a solution of a non-
2 electrochemically reactive salt, having an approximately equivalent ionic
3 concentration as the metal-containing liquid.
- 1 3. The method of claim 2, wherein the catholyte solution is a ferric sulfate solution and
2 the used catholyte solution is a ferrous sulfate solution.

- 1 4. The method of claim 3, additionally comprising regenerating a ferric sulfate solution
2 from the ferrous sulfate solution by bubbling a gas through the ferrous sulfate
3 solution, wherein the gas is selected from the group consisting of air and oxygen.

- 1 5. The method of claim 3, wherein the anolyte solution is a solution of approximately
2 equal ionic concentration as the intermediate liquid, selected from the group
3 consisting of sodium salt solutions and sulfate salt solutions.

- 1 6. The method of claim 5, wherein the anolyte solution is selected from the group
2 consisting of sodium sulfate and ferrous sulfate.

- 1 7. The method of claim 1, wherein the anolyte solution is a solution of approximately
2 equal ionic concentration as the intermediate liquid, selected from the group
3 consisting of sodium salt solutions and sulfate salt solutions.

- 1 8. The method of claim 7, wherein the anolyte solution is selected from the group
2 consisting of sodium sulfate and ferrous sulfate.

- 1 9. The method of claim 1, wherein the electrical current in at least one of the first and
2 second placing of the anode and cathode in electrical communication with a power
3 source is between about 1 ampere and about 10 amperes.

- 1 10. A method for treating a metal-containing liquid, wherein the metal-containing liquid
2 also comprises reducing agents, the method comprising:
3 providing a reaction vessel containing an anode, a cathode, and a hydrogen
4 ion-permeable membrane separating the anode and the cathode;
5 disposing the metal-containing liquid in the reaction vessel in contact with the
6 cathode;
7 disposing an anolyte solution in the reaction vessel in contact with the anode;
8 placing the anode and cathode in electrical communication with a power
9 source and driving an electrical current through the anode and the cathode until at
10 least a majority of the metal ions in the metal-containing liquid are plated onto the
11 cathode to produce an intermediate liquid;

12 removing the intermediate liquid from contact with the cathode and the
13 anolyte solution from contact with the anode, optionally from the reaction vessel
14 separately to a first and a second reservoir respectively;

15 disposing the intermediate liquid in contact with the anode;

16 disposing a catholyte solution in contact with the cathode; and

17 a second placing the anode and cathode in electrical communication with a
18 power source and driving an electrical current through the anode and the cathode until
19 at least a majority of the reducing agents in the metal-containing liquid are oxidized to
20 provide a treated solution.

1 11. The method of claim 10, wherein the catholyte solution is a solution of a ferric salt,
2 having an approximately equivalent ionic concentration as the intermediate liquid.

1 12. The method of claim 11, wherein the ferric salt is ferric sulfate and the used catholyte
2 solution is a ferrous sulfate solution.

1 13. The method of claim 12, additionally comprising regenerating a ferric sulfate solution
2 from the ferrous sulfate solution by bubbling a gas through the ferrous sulfate
3 solution, wherein the gas is selected from the group consisting of air and oxygen.

1 14. The method of claim 12, wherein the anolyte solution is a solution of approximately
2 equal ionic concentration as the intermediate liquid, selected from the group
3 consisting of sodium salt solutions and sulfate salt solutions.

1 15. The method of claim 14, wherein the anolyte solution is selected from the group
2 consisting of sodium sulfate and ferrous sulfate.

1 16. The method of claim 10, wherein the anolyte solution is a solution of approximately
2 equal ionic concentration as the intermediate liquid, selected from the group
3 consisting of sodium salt solutions and sulfate salt solutions.

1 17. The method of claim 16, wherein the anolyte solution is selected from the group
2 consisting of sodium sulfate and ferrous sulfate.

- 1 18. The method of claim 8, wherein the electrical current in at least one of the first and
2 second placing of the anode and cathode in electrical communication with a power
3 source is between about 1 ampere and about 10 amperes.